Codes and Standards Climate Strategy

Pat Eilert, Pacific Gas and Electric Company
Eric Rubin, Alex Chase, Energy Solutions
Yanda Zhang, YDZ Energy

ABSTRACT

Traditionally, California's building energy codes and appliance energy standards ("Codes and Standards") have focused primarily on reducing energy consumption and peak demand for electricity by mandating energy efficiency measures. Today, California has a variety of significant energy and climate policy goals, expressed in executive orders, legislative bills, and state agency action plans. While energy efficiency is fundamental for achieving many of these goals, it is only one component. California's statewide goals are diverse in scope, including targets over the next 35 years for energy efficiency, renewable energy, battery storage capacity, zero net energy (ZNE) buildings, and zero-emission vehicles (ZEVs). If California is to achieve these multifaceted goals, Codes and Standards must be deployed holistically and vigorously with these goals in mind.

This paper summarizes Pacific Gas and Electric Company's Codes and Standards evolving Climate Strategy. First, we quantify the potential for the traditional function—increasing end-use energy efficiency—to contribute to California's long term goals. Second, we explore how Codes and Standards can be a powerful tool for decarbonizing energy production and usage more broadly. For example, we investigate strategies for increasing rooftop solar generation, encouraging battery storage, developing electric vehicle infrastructure, and creating "smart homes" served by appliances that shift their time of use to match renewable energy production. Finally, we assess the regulatory, legal, and technical barriers to realizing these opportunities and explore associated solutions. The results and recommendations are presented through a California lens but provide valuable insights for other states and nations.

Introduction

For nearly 40 years, California's building energy codes (Title 24)[1] and appliance energy standards (Title 20) have focused primarily on reducing energy consumption and peak demand for electricity by mandating energy efficiency measures that are shown to be cost-effective and technically feasible (CEC 2015a; CEC 2015b).California's Investor-Owned Utilities (CA IOUs) including Pacific Gas and Electric Company (PG&E), have been active in ensuring that California's Title 24 and Title 20 regulations keep pace with cost-effective efficiency opportunities. To date, the IOUs primarily have provided support by researching and writing Codes and Standards Enhancement Reports (CASE Reports) that identify efficiency measures and recommend specific revisions to the code language, which are generally adopted by the California Energy Commission (CEC) with modifications pursuant to a public rulemaking process. PG&E and the other California IOUs also support the development of the Department of Energy's (DOE) federal appliance standards. Since 2004, the IOUs have done so by leveraging

[1] Title 24 includes Part 6, which are mandatory energy standards, and Part 11, which is California mandatory and voluntary Green Building Code (often referred to as "CALGreen.")

available IOU and market data to help refine rulemaking analyses and by submitting recommendations for enhancing standards in development during the public commenting period.

The CA IOUs' codes and standards advocacy has been enabled greatly by California's policy of revenue "decoupling." Since 1982, the California Public Utilities Commission (CPUC) has determined the CA IOUs' target revenue, taking into account the costs of energy supply and demand-reducing programs and building in an appropriate rate of return for investors, and set the IOUs' electricity and natural gas rates accordingly (CPUC 2015b). CPUC also sets the savings goals that define the official success of the IOUs' efficiency programs and codes and standards advocacy. Thus far, these goals have been set in terms of avoided GWh, MMtherms, and peak MW, but the recent Senate Bill 350 (SB 350) could herald a paradigm shift, stating: "The Legislature finds and declares that, in addition to other ratepayer protection objectives, a principal goal of electric and natural gas utilities' resource planning and investment shall be to minimize the cost to society of the reliable energy services that are provided by natural gas and electricity, and to improve the environment and to encourage the diversity of energy sources through improvements in energy efficiency, development of renewable energy resources, such as wind, solar, biomass, and geothermal energy, and widespread transportation electrification."

In response to an increasingly holistic regulatory environment and the broader climate crisis, PG&E's Codes and Standards program is developing its Climate Strategy: a vision for how PG&E's Codes and Standards advocacy can be enhanced in scale and scope to help meet California's aggressive, multifaceted climate goals. Section I of this paper describes our modeling of the potential for building codes and appliance standards to help meet California's goal of "doubling energy efficiency" by 2030 (i.e. achieving 100% more energy savings than the utilities' original goals). Section II outlines how the greenhouse gas (GHG)-mitigating benefits and applications of Codes and Standards can extend beyond simply increasing end use energy efficiency in buildings—accelerating the decarbonization of the transportation sector and of electricity production. Section III considers the structural limitations to realizing the full GHG savings potential of Codes and Standards and explores possible solutions.

I. The Role of Codes and Standards in Doubling Energy Efficiency

California's most aggressive and overarching energy efficiency goal is currently to "double energy efficiency" by 2030, as prescribed by Senate Bill 350 (SB 350). Doubling efficiency is critical to achieving California's long term, statewide GHG reduction goals. When the consulting firm Energy + Environmental Economics (E3) created detailed, scenario-based models of how California could cost-effectively reach its 2050 GHG goals of reducing GHGs to 80% below 1990 levels, all of their successful modeling scenarios required a doubling of energy efficiency achieved in buildings and industry, relative to current policy (E3 2015).

SB 350 defines "doubling efficiency" as twice the IOUs' Additional Achievable Energy Efficiency (AAEE) savings forecasted by the CEC plus twice the efficiency goals of the publically owned utilities (POUs) (California Senate 2015). We set out to quantify the potential for Title 24, Title 20, and federal appliance standards to contribute to the SB 350 goal, measured in terms of GHGs. We included business-as-usual savings from efficiency incentive programs ("Programs") in the model to provide a fuller context for progress toward the SB 350 goal. Other energy efficiency efforts that we did not model but which will be counted toward the 2030 goal include Property Assessed Clean Energy (PACE) programs and Community Choice Aggregation (CCA) energy efficiency incentive programs (California Senate 2015).

Figure 1 summarizes the high-level results of our savings potential analysis from 2016-2030. We calculate that business-as-usual savings from Programs will achieve 40% of the 2030 SB 350 goal. The additional savings from Codes and Standards that have already been adopted but which were not included in the baseline for the SB 350 goal ("Adopted C&S") will increase total savings to 58% of the 2030 milestone. Adding savings from likely future C&S (measures that have not yet been adopted) results in the total savings from business-as-usual Programs and C&S: 79% of the 2030 goal. Given three potential, aggressive expansions to business-as-usual C&S (described in more detail below), we estimate that California could double efficiency by 2030, reaching 101% of the 2030 goal.

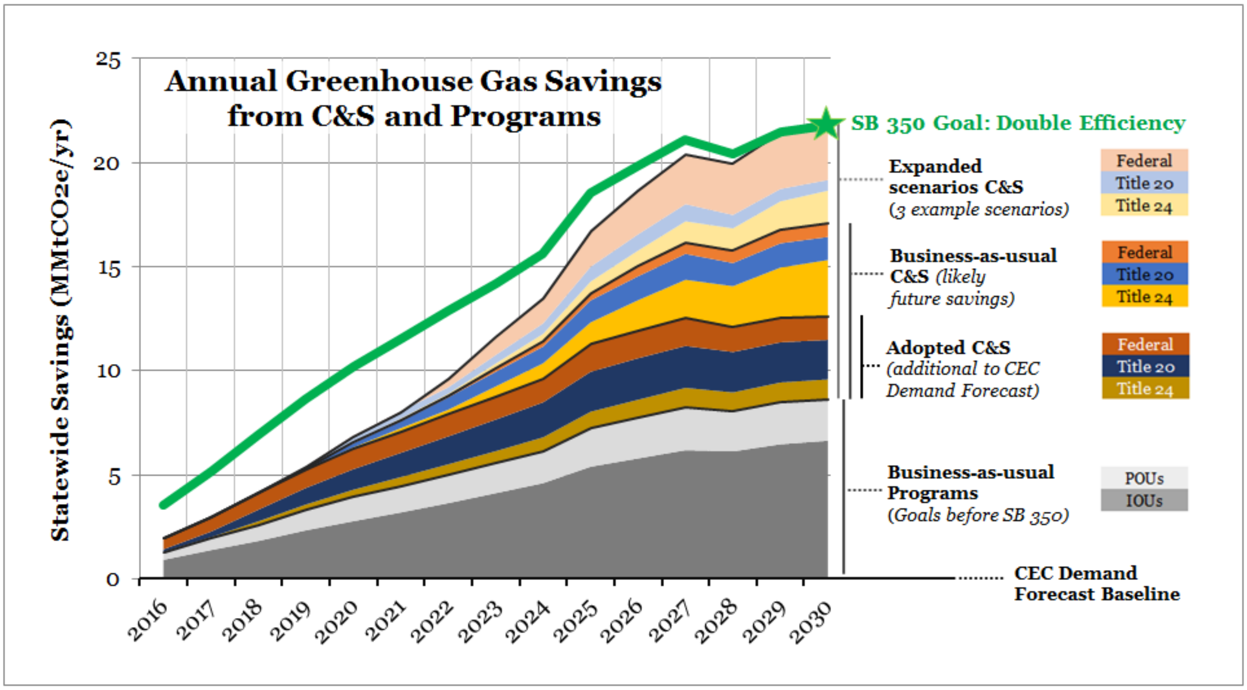

Figure 1. Forecasted GHG savings from Codes and Standards (C&S) and Incentive Programs (Programs) compared to California's goal of doubling energy efficiency as defined by SB 350. All savings are additional to the savings accounted for in the 2015-2025 CEC Demand Forecast baseline, which is the baseline for the 2030 goal (CEC 2014). C&S savings are discounted by subtracting our estimates of non-compliance and naturally occurring market adoption (NOMAD), which are broadly consistent with the underlying C&S AAEE assumptions that informed the SB 350 goal. All GHG savings are statewide; however, the calculation of the SB 350 goal as defined in the Senate bill language does not include C&S savings that occur outside of IOU territory. We quantified the SB 350 doubling efficiency goal using analysis conducted by NRDC, which followed the methodology prescribed in the Senate bill language (NRDC 2015). We converted electricity and natural gas savings/goals to GHGs using the year-dependent emissions factors in E3's PATHWAYS model, choosing the "Straight Line" scenario because the penetration of renewables in that scenario nearly identical to the trajectory that is currently mandated by California's Renewable Portfolio Standard (RPS) (E3 2015). These emissions factors produce a noticeable hump around 2025 due to the decommissioning of the Diablo Canyon nuclear plant, which PATHWAYS models will yield a temporary increase in the emissions intensity of electricity (E3 2015).

Table 1 provides additional detail on the sources of savings in the business-as usual scenario (i.e. without expansion to C&S). Collectively, we estimated that business-as-usual C&S and Programs can achieve 79% of the 2030 SB 350 goal.[2]

Table 1. Overview of savings categories included in the business-as-usual scenario

Scenario Category	Description
Adopted C&S	Those C&S measures that have already been adopted since the 2015-2025 CEC Demand Forecast. Savings estimates are largely based on the ex-ante estimates published by CEC and DOE.
Additional, likely C&S	Specific C&S measures or rate of C&S savings we expect in a business-as-usual scenario, based on current plans and historical precedent. We employed distinct approaches for Title 24,[3] Title 20,[4] and Federal[5] measures.
Business-as-usual Programs	Savings from IOU Programs, derived from CEC's mid-case projection of AAEE savings, and POU Programs, derived from on the POUs' savings targets (CEC 2014; CMUA 2015). Savings projected through 2030 using average annual growth rate.

The three expanded scenarios to C&S, as shown in Figure 1 could yield almost a quarter of the 2030 SB 350 savings goal (23%). These expanded scenarios are:

- **Title 24: More aggressive efficiency levels and more retrofits affected.** In the expanded Title 24 scenario, we assume that each future Title 24 code cycle has 30% higher efficiency levels than we assumed in the business-as-usual scenario. We also assume a 15% increase in code-triggering commercial retrofits.
- **Title 20: Double the rate of Title 20 measure adoption.** The expanded Title 20 scenario includes ten more measures, largely drawn from the IOUs' long-term Title 20 prioritization effort, conducted in 2015. In practice, doubling the Title 20 adoption rate would require the creation of a long term measure adoption schedule which would give stakeholders a clear vision for timing and encourage advocates and industry engagement in advance of pre-rulemakings. The process would also benefit from a more rigorous data collection and sharing process, to address the increasing complexity of appliance standards, and the necessary feasibility and cost-effectiveness analysis.
- **Federal: Enhanced C&S for federally covered product categories (through DOE activity or a preemption waiver).** The expanded Federal scenario assumes that we

[2] Although one might expect that business-as-usual savings would be 50% of the doubling efficiency goal, this is not the case because CEC's estimate of Additional Achievable Energy Efficiency (AAEE) from C&S used to define the SB 350 goal is very conservative, particularly in its treatment of longer term savings opportunities.

[3] Title 24 savings are estimated using a top-down approach within each sector and technology type, generally assuming a rate of savings congruent with historical precedent. Title 24 savings are assumed to be implemented on the traditional three-year California code cycle. The largest source of additional, likely Title 24 savings in the model are commercial LED retrofits.

[4] Title 20 and federal appliance savings are estimated in a bottom-up approach, as the sum of specific measures. The list of Title 20 measures includes those published in the CEC's March 2012 Order Instituting Rulemaking, with some modification, as well as other topics previously identified for an IOU long-term prioritization effort conducted in 2015.

[5] Federal measures include those that are in development but not yet adopted and for which DOE has already published savings estimates. We also assume the legally required federal standards updates will occur every eight years with diminishing savings. Due to a lack of data availability, we did not estimate savings from federal standards that are not under development for currently unregulated product categories. As a result, the business-as-usual federal savings estimate is conservative.

achieve substantially more savings from federally regulated appliances. One way to achieve these savings would be for DOE to be more aggressive in its efficiency levels and rate of standards adoption.[6] Otherwise, the only way to realize this expanded savings potential would be if California obtains a federal preemption waiver. Even though California has the political will to set Title 20 and Title 24 standards for these product categories (and to require higher efficiency levels than DOE would set), it is currently illegal to do so: a federal preemption provision prohibits any "State regulation, or revision thereof, concerning the energy efficiency, energy use, or water use of [a product covered by a federal efficiency standard] with respect of such covered product" (Klass 2010). States can request a preemption waiver based on "unusual and compelling State or local energy or water interests" that are "substantially different in nature or magnitude than those prevailing in the United States generally"; however, DOE has never granted a preemption waiver and these waivers have previously not been seen as a viable pathway (Klass 2010). Given SB 350 and California's aggressive goals of doubling efficiency and reducing GHGs 80% below 1990 levels by 2050, we recommend that the CEC explore applying for a federal preemption waiver on the grounds that these challenges constitute unusual and compelling State energy interests. To calculate the expanded Federal potential, we began with a 2012 estimate of the savings California could achieve with a statewide preemption waiver,[7] and subtracted federal savings in the business-as-usual scenario.

II. Beyond Building and Appliance Efficiency

Ultimately, achieving a doubling of energy efficiency in buildings and industry by 2030 is only one component of reaching California's long term GHG goals. Figure 2 provides a larger context for the relative GHG mitigation of doubling efficiency versus other policies and targets. The light gray area represents California's historical emissions, in MMtCO2e/yr (CARB 2013). The dark gray area represents California's GHG budget—a limit for the trajectory of statewide annual emissions if California is to meet the eventual goal of GHGs 80% below 1990 levels by 2050 (E3 2015). The colorful wedges show the contributions that different state and federal policies and targets will have toward reducing California's GHG emissions, if they are achieved. For example, the green "Efficiency" wedge is equivalent to the SB 350 efficiency goal shown in Figure 1, and the yellow "ZNE PV" wedge represents the rooftop solar associated with Zero Net Energy buildings[8] (Greenblatt 2015). The purple "Transportation" wedge includes Governor Jerry Brown's goal that there be 1.5 million ZEVs on the road by 2025 as well as federal and state vehicle efficiency standards (Greenblatt 2015). The "Renewable Portfolio Standard" (RPS)

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[6] During the Obama Administration, DOE has already adopted updated or new efficiency standards for 43 products, compared to 8 completed during the previous 8 years under President Bush (Crawford 2016).

[7] 2012 ACEEE Paper "Federal Appliance Standards Should be the Floor, Not the Ceiling: Strategies for Innovative State Codes & Standards" (Chase, McHugh, and Eilert 2012). This analysis evaluated the savings potential if standards were established at the best-on-market efficiency level for a selection of lighting, HVAC, appliances, and water heating product categories.

[8] The ZNE wedge assumes: 100% of new homes are ZNE by 2020; 100% of new commercial buildings and 50% of commercial retrofits are ZNE by 2030; savings grow slowly due to the long turnover time of buildings; new construction is assumed to occur at a rate of 1-2% per year and commercial retrofits at a rate of 0.3% per year (Greenblatt 2015). The PV associated with ZNE buildings offsets their remaining energy use, after accounting for energy use reductions from efficiency (Greenblatt 2015).

wedge is dominated by California's legislative mandate that 50% of electricity generation come from eligible renewables by 2030, but it also includes commitments by local governments to exceed the statewide RPS goals (Greenblatt 2015).

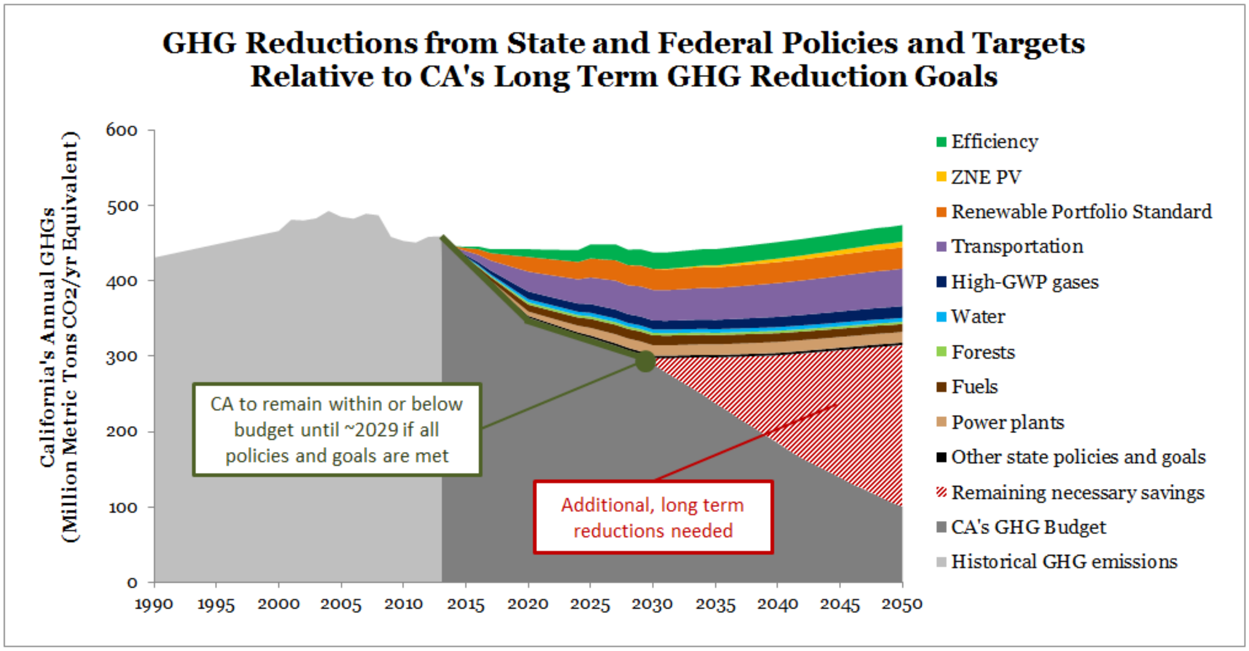


Figure 2. GHG Reductions from State and Federal Policies and Targets Relative to CA's Long Term GHG Reduction Goals. Policy wedges derived from LBNL's CALGAPS GHG model, "S2" scenario: Current CA Policies and Targets, including those without committed funding and detailed plans (Greenblatt 2015). "Efficiency" wedge equivalent to the SB 350 goal in Figure 1. CALGAPS wedges scaled linearly to harmonize with PATHWAYS "Baseline" scenario, which was adjusted upward to be consistent with the CEC Demand Forecast Baseline.

The implication of the large, red wedge of "Remaining Necessary Savings" is that current policies and targets are enough to keep California within its GHG budget through 2029—if all policies are continued and targets achieved—but additional, long term policies and targets must be identified and implemented to reach the 2050 GHG goal. For example, the Efficiency wedge does not continue to grow after 2030, because California does not have a goal of continuing to double efficiency through 2050.[9]

Based on GHG modeling from Lawrence Berkeley National Lab's (LBNL) CALGAPS model and E3's PATHWAYS models, both of which were used to inform Figure 2, some of the most important ways to expand the wedges above include: continuing to double (or more than double) the rate of energy efficiency after 2030; continuing to increase vehicle efficiency standards and shift market share to ZEVs; and increasing the share of renewables from 50% in 2030 to 75-85% in 2050. In the following section, we demonstrate how Codes and Standards can help to facilitate these ambitious technological and market transitions.

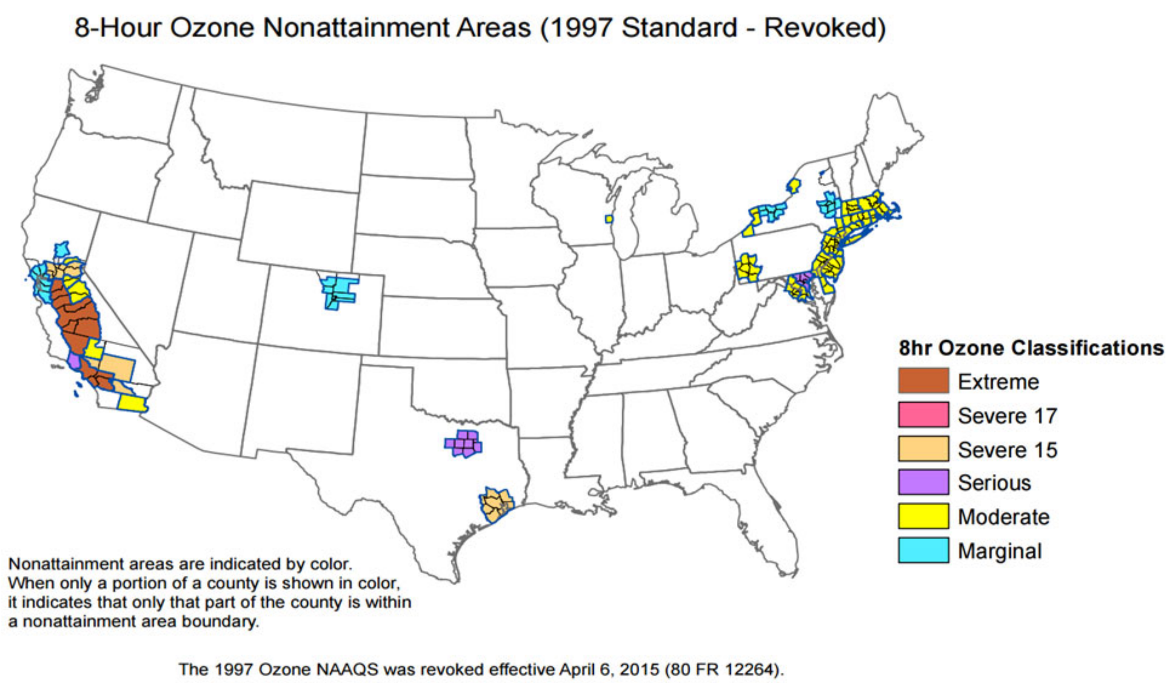
[9] There are myriad sectoral and cross-sectoral mitigation pathways and measures associated with: energy supply; energy end-use sectors; agriculture, forestry, and other land use (AFOLU); and human settlements, infrastructure and spatial planning. Many of these are beyond the scope of this paper but a good starting point is the Fifth Assessment Report (AR5) by Intergovernmental Panel on Climate Change (IPCC).

II.a. Decarbonizing the Transportation Sector

The transportation sector is the largest contributor to California's GHG emissions, accounting for 37% of statewide emissions according to the California Air Resources Board (CARB). Governor Brown's Executive Order (EO) B-16-12 requires an 80% reduction in transportation sector GHGs by 2050 relative to 1990 levels. Improvements to conventional combustion technologies are essential to meet this goal but not sufficient.

More electric vehicles and supporting infrastructure will also be needed. Electric vehicles are also needed as a flexible resource to integrate increasing levels of renewable electricity on the grid.[10] California has therefore recognized the importance of deploying electric vehicles: EO B-16-12 sets a target of 1.5 million plug-in electric vehicles (PEVs) and other zero emission vehicles (ZEVs) by 2025.

Finally, converting to electric vehicles is vital to addressing the negative impacts of transportation on air quality and public health. The transportation sector accounts for 83 percent of statewide nitrogen oxides (NOx) emissions (CARB 2013). NOx and hydrocarbons in the presence of sunlight are precursors of ground level ozone, a criteria pollutant which impacts lung function and increases deaths and asthma attacks (EPA 2016b). As shown in Figure 3, California has an extreme problem with ground level ozone. Converting from gasoline to electric vehicles reduces GHG emissions by 79% and NOx emissions by 73%, thus addressing atmospheric pollutants and their impact on both climate and human health.[11]



[10] Plug-in electric vehicles can act as a flexible resource to help integrate renewables in several ways. The most immediate opportunity is drawing power from the grid when renewable energy is most abundant. Because solar PV and wind are variable and intermittent sources of electricity, flexible loads such as plug in electric vehicles may be used to ensure that the grid maintains a real-time balance of electricity generation and consumption.

[11] See Figure 16: *WTW (well-to-wheel) NOx emissions comparison* and Figure 19: *WTW GHG emissions comparison* (CARB 2011)

Figure 3. Map of areas not complying with the 8-hour ozone requirements in the Clean Air Act (EPA 2015).

Codes and Standards that enable electric vehicle infrastructure and yield additional efficiency improvements to non-electric vehicles can support these state policy goals, as we discuss in the following sections.

Summary of Transportation-Related Building Codes and Appliance Standards to Date. There is a precedent for building codes that support the development of ZEV infrastructure. The current CALGreen codes (Title 11 Part 24) contain mandatory requirements for plug-in electric vehicle (PEV) parking spaces in new single family and multi-family housing and nonresidential buildings. These codes focus on requiring electrical infrastructure with the capacity to support PEV charging.[12] Codes for multi-family housing—a key challenge to expanding the PEV market—were adopted in 2014 and require that 3% of parking space at new developments with 17 or more units will be PEV capable. More recently, revised CALGreen codes for nonresidential buildings were updated in January 2016 by the Building Standards Commission to require that 6% of parking spaces will be PEV capable. The CALGreen code also has a requirement for one PEV capable charging space at single family and duplex housing, and includes voluntary standards that local governments can adopt if they wish.

Although California does not currently have transportation-oriented Title 20 appliance standards, the U.S. Environmental Protection Agency (EPA) has proposed a voluntary ENERGY STAR™ specification for electric vehicle service equipment (EVSE). These standards can encourage the most energy efficient PEV charging, increasing the already wide efficiency advantage of PEVs over conventional vehicles.

Enhance and Expand Electric Vehicle Infrastructure Standards. The greatest potential for IOU advocacy for codes and standards to reduce greenhouse gases from the transportation sector is to continue to support California's transition to ZEVs, largely through voluntary and mandatory building codes that require PEV charging infrastructure.

More specifically, multi-family CALGreen residential building code could be improved by: (1) eliminating the exception that multifamily buildings with 3 to 16 dwelling units do not need to provide PEV charging infrastructure, (2) increasing the quantity of required PEV-ready parking spaces in newly constructed multifamily buildings from the current minimum of 3%, and (3) including a new trigger for PEV readiness requirements when parking facilities are renovated. The requirements for nonresidential buildings could be improved by (1) increasing the number of PEV-ready parking spaces to match state PEV deployment goals, and (2) including a new trigger for PEV readiness requirements when parking facilities are renovated. The requirements for single-family housing could be improved by requiring a complete charging circuit. In addition, CALGreen could require the installation of some EVSE at the time of construction to match current demand.

There are also a number of opportunities to improve charging infrastructure requirements by encouraging local jurisdictions to adopt local ordinances and potentially leveraging existing CALGreen voluntary codes. Local jurisdictions can adopt the CALGreen voluntary code

[12] **T**he builder must size the electrical panel with capacity for PEV charging, prepare plans for completing the circuit**,** and install any conduit that cannot be surface mounted later to a junction box near the parking space.

verbatim, which would then become mandatory at the local level, or they can develop local ordinances that best meet local needs including coordination with transportation and general plans.

While increased PEV-ready parking for light-duty vehicles is critical to supporting PEV adoption, many other opportunities exist for reducing transportation GHGs through the building code. For example, warehouses could be required to install infrastructure for electric forklifts and Standby Transportation Refrigeration Units (TRUs).[13]

Support Vehicle Efficiency and GHG Standards. Eventually California must shift to ZEVs, but in the near term the vast majority of vehicles rely on fossil fuel combustion. Tire efficiency standards for replacement tires increases fuel efficiency of passenger vehicles by approximately 4%, on average (Pike and Schneider 2013). The U.S. Department of Transportation has been required to adopt minimum standards for the fuel efficiency of passenger vehicle tires, and PG&E can support the implementation of these standards through technical research and advocacy.[14]

Another opportunity for increasing the efficiency of conventional vehicles is to help close potential loopholes to the current federal vehicle efficiency standards through research and advocacy for the U.S. EPA. From 2016 through 2018, California (led by CARB) and U.S. EPA will be conducting a joint "mid-term evaluation" of current California and U.S. EPA passenger vehicle GHG standards for model years (MY) 2017-2025. The review will address potential rule revisions that would affect MY 2022-2025 vehicles. Federal standards, which California has agreed to accept as equivalent to California standards, currently allow the issuance of energy-saving credits for technologies such as advanced heating and cooling, lighting, and electrification technologies and in some cases allow credits without verifying real world performance. Because some types of credits are issued without an adequate test procedure that proves real-world performance, manufacturers could claim undue credits, allowing them to nominally comply with the standard while falling short.[15] By updating antiquated test procedures and algorithms used to calculate the energy budget of the car, vehicle efficiency standards can properly incentivize energy-saving functionalities like LED lighting, advanced aerodynamics, and high efficiency heat pumps, and detect non-compliant manufacturers.

II.b. Decarbonizing Electric Production

In addition to establishing the doubling of efficiency goal, SB 350 requires that 50% of California's electric generation come from renewable sources by 2030. Based on GHG modeling from E3's PATHWAYS models, California must further increase the share of renewable electricity generation to 75-86% by 2050 to stay within its GHG budget[16] (E3 2015). Distributed

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[13] Electric TRUs use a mature technology that can displace very large quantities of diesel air pollution by powering refrigerated truck trailers with electricity as opposed to diesel when the truck is parked. PG&E can support a PEV-readiness standard for TRUs that requires panel capacity, underground conduits, and potentially also a full circuit at new and renovated warehouses.

[14] For example, PG&E can leverage prior research by consultants on behalf of the International Council on Clean Transportation to promote standards at least at strict as current EU standards.

[15] As one example of automakers attempting to evade environmental rules, US EPA has issued a Notice of Violation of the Clean Air Act to Volkswagen, Audi, and Porsche for allegedly installing software that reduces emissions only during the EPA test procedure but not during regular use of the vehicle (EPA 2016a).

[16] A commonality across all of the "backcasting" scenarios in E3's PATHWAYS model was that 75-86% renewables by 2050 was necessary in order to have California achieve 80% below 1990 emissions by 2050 (E3

generation does not count toward the 50% renewable portfolio standard (RPS), but Governor Jerry Brown has set the additional goal 12,000 MW of distributed generation by 2020 and CPUC has set aggressive ZNE goals that will require on-site renewables generation (Greenblatt 2015).

One of the most fundamental challenges to renewables is that increased renewable production makes the overall portfolio of grid-supplied electricity less predictable and more difficult to control, as electricity output from wind and solar vary based on weather, whereas output from a network of power plants can be managed meticulously. As more electricity is produced from renewable sources, forecasters expect net load dips during the mid-afternoon with the potential for over-generation followed by a dramatic ramp up to peak demand in the evening—a load profile commonly referred to as the "duck curve."

Codes and Standards can enable a major ramp up in renewable generation and address the inflexible and unpredictable nature of renewable electricity by embracing an Integrated Distributed Energy Resources (IDER) framework. IDER components can be combined to not only minimize energy use, but also to reshape load profiles so they match the pattern of renewable electricity production.

Summary of Codes and Standards IDER to Date. Building codes are ahead of other Codes and Standards instruments in integrating requirements for IDER components (other than energy efficiency), in part because building codes can tailor requirements based on climate zone and building attributes. For example, the 2008 Title 24 Standards, which took effect in January 2010, included mandatory requirements for all nonresidential HVAC systems to have control systems capable of shedding load by way of modifying temperature set points. Since the 2013 Title 24 standards that took effect in July 2014, lighting systems in nonresidential buildings larger than 10,000 square feet must be capable of shedding load by reducing lighting connected load by at least 15 percent. Large outdoor message center signs over 15 kW are also required to have demand responsive controls.[17] The impacted HVAC and lighting systems must be equipped with demand response (DR) controls that are capable of automatically initiating the load sheds in response to a DR signal.

Title 24 also includes mandatory solar-ready requirements. In residential buildings, on-site solar PV can be used to meet the required energy budget; however, electricity generated from solar PV systems is greatly discounted. Furthermore, 2016 CALGreen standards include a voluntary ZNE Tier for residential buildings. To comply with the voluntary ZNE Tier, the building must achieve an Energy Design Rating of zero (0) as calculated using the Title 24 compliance software. This will require an appropriately-sized on-site renewable generation system to be installed at the time of construction. The CPUC has a target of ZNE for all newly constructed homes by 2020 and for all newly constructed commercial buildings by 2030.

While there are no mandatory California-specific or federal appliance standards that require devices to have demand response (DR) capability, there are five ENERGY STAR specifications that provide a five percent compliance credit if the product meets the Connected Product Criteria, which includes a requirement for demand response capability.[18]

2015). The exception to this is the Carbon Capture and Storage (CCS) scenario; however, there are major risks to relying on future advancements in CCS to balance California's budget (E3 2015).

[17] Title 24 requires Electronic Message Centers (EMCs) with a new connected load over 15 kW to have DR controls and be capable of reducing lighting power by 30 percent if a DR signal is received.

[18] The ENERGY STAR specifications for the following products include a Connected Product Criteria credit: clothes dryers, residential clothes washers, residential dishwashers, residential refrigerators and freezers, room air conditioners. The credit can be traded against efficiency.

IDER Building Codes. There are a number of opportunities to induce IDER through the building code including: adding or modifying mandatory DR requirements; adding acceptance tests to ensure systems are commissioned correctly; developing prescriptive requirements and/or additional compliance options (only after ensuring efficiency is pursued first); and establishing more stringent IDER requirements in locations where the distribution systems are strained by way of local ordinances. We discuss a selection of these opportunities in more detail below.

The existing mandatory DR control requirements in Title 24 could be strengthened by harmonizing communications requirements for all Title 24 DR controls. Currently, communications requirements for Occupant Controlled Smart Thermostats (OCSTs), which are specified in Joint Appendix 5, are very detailed and perhaps overly specific, while communications requirements for DR lighting controls and more sophisticated HVAC controls are vague and non-specific. To ensure interoperability, it is desirable for all controls to adhere to the same minimum standardized communications requirements. Existing requirements would benefit from simplification and clarification, which could lead to improved compliance. It may also be appropriate to require DR controls in more buildings. For example, Title 24 could require OCSTs in all newly constructed residential buildings.

The performance approach provides builders with a flexible pathway to achieve the required energy budget, giving builders leeway to experiment with new technologies and design approaches. Although the performance approach is intended to provide compliance options, it is limited in that builders can only receive compliance credit for approaches that have approved modeling rules. Approved compliance credits for IDER systems other than efficiency and DR are limited in part to ensure builders pursue efficiency first, thereby maintaining the “loading order” of prioritizing cost-effective energy efficiency before demand response or renewables and lastly nonrenewable sources (CEC and CPUC 2005).[19,20] Once a framework is place to ensure the loading order is maintained, prescriptive requirements and/or modeling rulesets could be developed or updated for: solar PV systems, on-site battery storage systems, thermal storage HVAC systems, building control systems that have default programing to optimize all IDER components within a building, controlled electric vehicle charging, and electric water heaters with DR capabilities.

IDER Appliance Standards. In the near term, it may be appropriate to establish energy performance requirements for smart inverters, battery storage systems (e.g. round trip efficiency and discharge capacity), and standby power use for a wide variety of connected devices.

[19] There are limited DR compliance credits in Title 24 because it is not desirable to allow efficiency measures, which have reasonably assured energy savings, to be traded for DR measures, which only yield savings if the building occupant chooses to participate in DR programs. Instead of offering DR compliance options, DR requirements in Title 24 are mandatory. This means certain buildings must have DR capabilities, and these DR requirements cannot be traded against efficiency.

[20] The 2016 Title 24 Standards allow builders to install solar-PV to meet a portion of the required energy budget for residential buildings. Solar PV systems will contribute to the whole-building Energy Design Rating that is used to demonstrate compliance with the ZNE Tier in CALGreen. The CALGreen requirements were crafted to ensure that buildings meet a minimum level of energy efficiency before applying credit from solar PV systems. There is also an approved modeling approach for HVAC systems with thermal (ice) storage.

Connected devices have higher standby power draws than non-connected devices so requirements that establish maximum allowable standby power use could mitigate potential growth in electricity use as more devices become connected.

In California, the Title 24 includes requirements for IDER devices, but the building code compliance and enforcement (C&E) processes are not well-suited to verify compliance with these device requirements. For example, Title 24 requires OCSTs be installed in nonresidential buildings if energy management control systems with global temperature adjustment controls are not used.[21] CEC's Title 24 staff is responsible for certifying compliant OCSTs and posting a list of approved OCSTs on the Title 24 section of CEC's website. Given the complexity and of the building code and the sheer volume of code requirements, a C&E process that requires code officials to navigate multiple lists of approved devices can lead to noncompliance. One potential solution is to leverage the robust and effective Title 20 C&E process to simplify compliance with Title 24 device performance requirements. This could be accomplished in several ways: Title 24 staff could continue to certify Title 24-compliant products and devices, but compliant products could be listed in CEC's Appliance Efficiency Database.[22] Alternatively, Title 24 device requirements could be incorporated into the Title 20 purview by adopting Title 20 test and list requirements. Test and list standards require manufacturers to test their products using a specified test method and submit the results to CEC by way of the Title 20 C&E process. The following devices could benefit from being incorporated into the appliance standards C&E process: PV modules, smart inverters, on-site energy storage systems, OCSTs, and other HVAC equipment. [23]

IDER Benefits of Electric Vehicle Service Equipment Standards. Managed EV charging is an important nexus between transportation- and IDER-focused Codes and Standards, since EVSE standards can facilitate demand response (DR). For example, US EPA is currently developing voluntary ENERGY STAR DR standards, which are focused on providing information regarding EVSE DR capabilities for EVSE with the participation of the IOUs.

PG&E could also support the development of CARB's planned standard for EVSE interoperability so that EV drivers could access any public EVSE with a single access card—similar to how ATMs operate. In a similar vein, the development of EVSE sub-metering standards could address requirements for data accuracy, data format, communications protocols, and more, to allow EV drivers to access favorable TOU EV rates without purchasing a separate meter. The sub-metering standards could be based on lessons learned from the current IOU EVSE sub-metering pilot.

IDER Design Specifications. Design specifications ensure product safety, reliability, and interoperability across the entire industry, regardless of the product manufacturer. These specifications are typically developed using a consensus process that allows participation from all interested stakeholders. Design specifications typically focus on safety and reliability, but some metric of energy performance is usually included. There are design specifications for most

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[21] OCSTs can also be installed in residential buildings instead of the solar-ready requirements.

[22] Title 24-compliant LED lighting products are certified by Title 24 staff and listed in California's Appliance Efficiency Database.

[23] Title 24 staff currently oversees compliance with equipment, device, and product requirements for: air economizers, airflow measurement apparatus—forced air systems, airflow measurement apparatus—ventilation systems, air-to-water heat pump systems, economizer fault detection and diagnostics, intermittent mechanical ventilation systems, low leakage air-handling units, and OCSTs: http://www.energy.ca.gov/title24/equipment_cert/.

components of IDSR systems (e.g. energy-using products, PV modules, inverters, batteries), but design specifications for integrated systems are lacking. For example, design specifications for communications protocols, bi-directional communication between energy loads and grid operators, are still evolving. Industry is working on specifications for smart inverters that could be coupled with on-site solar PV systems or on-site battery storage systems. There are no specifications that would standardize how controls should communicate information about their system operation to customers (e.g. symbols to use to indicate that daylighting controls are active).

III. Developing a More Holistic Codes and Standards Climate Strategy

Another consequence of SB 350 is that the CA IOUs and other Load Serving Entities (LSEs) will need to submit Integrated Resource Plans (IRPs) that address contributions toward statewide GHG reductions targets, progress toward 50% RPS, energy efficiency, demand response, energy storage, and transportation electrification (California Senate 2015). CPUC has until 2017 to adopt a process for each LSE to submit an IRP that meets the criteria above (California Senate 2015). CPUC has yet to determine how prescriptive the IRP process will be and the specificity/flexibility of the goals and methodology provided to the LSEs (CPUC 2015a).

The evolution underway with the IRP process holds an opportunity for Codes and Standards to: increase its efficiency goals as a means of doubling efficiency and reaching statewide GHG targets; reduce GHGs through more avenues, including measures like tire efficiency standards, DR-ready appliances, and even measures that reduce high-Global Warming Potential gas emissions;[24] and place more emphasis on addressing technology barriers, through consensus-based design standards, communications protocols, acceptance tests, test and list requirements and other such measures. There are multiple issues that need to be considered and addressed to achieve to this transformation.

First, new metrics and models are needed to quantify the costs and benefits of vehicle electrification and the various components of IDER, both in terms of time dependent energy cost value and GHGs. These models should take into account the effects of location and hour of the year and also change over time to reflect evolving grid conditions. A robust modeling framework is necessary for optimizing the selection of possible IDER- and transportation-related Codes and Standards measures and demonstrating cost-effectiveness.

Second, the IOUs must have sufficient flexibility in their IRP directives from the CPUC to implement IDER activities.

Finally, we envision a future where California's IDER portfolio(s) are focused primarily on achieving California's greenhouse gas reduction targets and related goals by investing in long-term integrated planning efforts focused on directed market transformation.[25] This includes

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[24] For example, rewarding the use of CO_2 heat pumps instead of traditional HFC heat pumps, which contain refrigerants with significantly higher Global Warming Potentials, and thus have higher direct GHG impacts when these refrigerants eventually leak.

[25] Directed market transformation includes intentional and specific activities executed to realize the outcomes in CPUC Decision (D.)09-09-047, which defined market transformation as "long-lasting, sustainable changes in the structure or functioning of a market achieved by reducing barriers to the adoption of energy efficiency measures to the point where continuation of the same publicly-funded intervention is no longer appropriate in that specific market. Market transformation includes promoting one set of efficient technologies until they are adopted into codes and standards (or otherwise adopted by the market), while also moving forward to bring the next generation of even more efficient technologies to the market."

investing in a deliberate process that saves more energy for less money by enabling the transition to Codes and Standards earlier in the product life cycle. The C&S program team helps to realize this vision by working with incentive and financing program staff and other cross-cutting programs to establish long-term goals for certain building types, systems, and/or classes of equipment. Once a future goal/vision is established, the teams then work backwards to develop *Integrated Plans* to be implemented in the near term. PG&E has started down this path with its new "Code Readiness" C&S subprogram,[26] which invests in activities that increase the market feasibility and accelerated commercialization of technology improvements needed to meet statewide goals. Code Readiness activities include: building demonstrations; incentive program measure development, and training and education. The key outcome is knowledge transfer between the C&S program, incentive programs, and industry stakeholders.

Conclusions

Codes and Standards has untapped potential to reduce GHG emissions and to help facilitate the decarbonization of transportation and electricity production. As discussed in Section I, energy efficiency from Codes and Standards will be pivotal to achieving (or exceeding) a doubling of efficiency in buildings and industry by 2030—particularly with the expansions to the current Codes and Standards program described in Section I. Beyond energy efficiency, there are ample opportunities for Codes and Standards to reduce GHGs from transportation—most notably, the ability to help address the chicken-and-egg problem that has blocked ZEV infrastructure development and thus ZEV adoption. Similarly, as renewable electricity sources replace fossil fuels, Codes and Standards can help maximize the use of clean energy and prevent grid unreliability through measures that help integrate energy storage, demand response, and energy management systems. In order for Codes and Standards to realize this potential, utilities and regulators need to set more aggressive, long term efficiency goals and think more broadly about the types of value the Codes and Standards Program can provide. There is still work to be done on developing the best metrics and goals, the necessary models, and codifying this expanded paradigm, but the first step is to cast off preconceptions and think strategically about Codes and Standards from a climate perspective.

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[26] CPUC approved a new *Code Readiness* PG&E local C&S subprogram for 2016. https://www.pge.com/nots/rates/tariffs/tm2/pdf/GAS_3656-G.pdf

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